

**East Fork Locust and Locust Creek  
*E. coli* Study  
Sullivan and Linn Counties, MO**

**July-August 2007**



Missouri  
Department of  
Natural Resources

Prepared for:

Missouri Department of Natural Resources  
Division of Environmental Quality  
Water Protection Program

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## **1.0 Introduction**

At the request of the Water Protection Program (WPP), the Environmental Services Program (ESP) conducted five *Escherichia coli* (*E. coli*) sampling events on East Fork Locust Creek and Locust Creek. This water quality study consisted of five sampling events over a five-week period. The sampling occurred between July 10, 2007 and August 7, 2007. The purpose of the sampling was to examine the impact of point and non-point sources on *E. coli* levels in East Fork Locust Creek and Locust Creek. This study is an expansion of the East Fork Locust/Locust Creek study of September 2006 that found potentially high levels of *E. coli* in East Fork Locust Creek. The 2007 water quality study covered in this report includes nutrient samples and additional sites that were not included in the 2006 study.

Mandy Sappington, Wayne Maresch, Bethany Meyer, and Randy Niemeyer of the ESP, Field Services Division performed sampling and analyses. Side-by-side *E. coli* samples were collected by Dr. Cynthia Cooper or ESP staff and analyzed at Truman State University. During the 2007 study, ESP and Truman State University used the IDEXX Colilert and Quantitray Test Method to analyze all samples. This provided more comparable results than those obtained in September 2006.

## **2.0 Study Area**

The study area included eight sites: four on East Fork Locust Creek, one on Elmwood Creek, and three on Locust Creek. East Fork Locust originates in southern Putnam County, northeast of Pollock, Missouri. East Fork Locust runs for approximately 15 miles through rural agricultural areas before it reaches Elmwood Creek, just north of Milan, Missouri. Elmwood Creek receives the discharge of Premium Standard Farms (PSF) Milan Processing Plant Wastewater Treatment Facility (WWTF) (MO-0115487). East Fork Locust then flows down the eastern edge of Milan for approximately three miles before receiving effluent from the Milan WWTF (MO-0048151). East Fork Locust flows for another 11 miles through rural, agricultural areas before entering Locust Creek 0.5 mile north of Browning, Missouri. East Fork Locust is a class C stream from its headwaters to Highway 6 in Milan, where it becomes a class P stream with designated uses for livestock and wildlife watering, protection of warm water aquatic life, and whole body contact recreation type B (WBC-B). There is a section of the stream excluded from whole body contact recreation-from Highway 6 to sec.23, T. 62 N., R. 20 W.; site 4 (near the Milan WWTF) is located in this section.

Locust Creek originates in Iowa and runs south through rural agricultural portions of Putnam and Sullivan counties. This portion of Locust Creek contains no point sources. Approximately 45 miles south of the Iowa border, East Fork Locust enters Locust Creek near Browning, Missouri. Just south of Browning, Locust Creek receives Browning WWTF (MO-0051616) effluent. Locust Creek is a Class P stream with designated uses for livestock and wildlife watering, protection of warm water aquatic life, WBC-B, secondary contact recreation, and drinking water supply.

## **2.1 Site Descriptions**

**Site 1** – (GPS Lat. 40.2835, Long. -93.0889) This site is located where Highway N crosses East Fork Locust. It is upstream of the PSF and Milan WWTF discharges. This section of the stream is categorized as Class C and classified WBC-B. The substrate here is primarily sand with some smaller silt particles. The riparian corridor is narrow along steep banks, with residential and agricultural land use in the area.

**Site 2** – (GPS Lat. 40.2196, Long. -93.1092) This site is located on Elmwood Creek downstream of PSF discharge. The site is accessed near the bridge crossing at Highway 5 via Milan Water Treatment Plant property. Elmwood Creek is an unclassified stream. The substrate at this site is primarily silt. There is a narrow riparian corridor upstream of the sampling site, but near the bridge the banks are covered with various grasses and shrubs. Land adjacent to this site is used for agriculture and commercial purposes.

**Site 3** – (GPS Lat. 40.2112, Long. -94.8944) This site is located where Highway 6 crosses East Fork Locust. It is approximately 0.35 mile downstream of Elmwood Creek and upstream of the Milan WWTF. This site is where the stream becomes Class P. The WBC-B classification is suspended immediately downstream of this site. The substrate here is primarily sand with some smaller silt particles. Adjacent land use includes residences and row crops, with commercial uses nearby.

**Site 4** – (GPS Lat. 70.1933, Long. -93.1144) This site is located on East Fork Locust downstream of the Milan WWTF effluent. It is accessed through the WWTF. This section of the stream is categorized as Class P and not classified for whole body contact recreation. The substrate here is a mixture of sand and silt. The banks near this site are high and steep. The riparian corridor is comparatively wide at this site. Adjacent land use is row crop. This site is also downstream of commercial land use in the town of Milan.

**Site 5** – (GPS Lat. 40.1639, Long. -93.1228) This site is located where Rolling Road crosses East Fork Locust. It is approximately 4.5 miles downstream of Elmwood Creek and 2.75 miles downstream of the Milan WWTF. At the sampling point the stream is categorized Class P and classified WBC-B. The substrate at this location is finer, with more silt than upstream sites. The riparian corridor is narrow along steep banks. Adjacent land use is row crops. Cattle were observed in the creek upstream of this site.

**Site 6** – (GPS Lat. 40.0641, Long. -93.1673) This site is located at a concrete slab bridge on Locust Creek at the Missouri Department of Conservation's Rocky Ford Access on Vernon Road. It is approximately 1.5 miles upstream of the East Fork Locust-Locust Creek confluence. The substrate at this site is dominated by bedrock. The riparian corridor is narrow, but contains more mature trees and shrubs than other sampling sites. Nearby fields are planted in row crops.

**Site 7** – (GPS Lat. 40.0354, Long. -93.1722) This site is located where Highway MM crosses Locust Creek. It is approximately 0.5 mile downstream of the East Fork Locust-Locust Creek confluence. The substrate here is primarily sand. Adjacent land use is row crops. The banks are

steep and mostly covered in herbaceous vegetation near the bridge. There are more trees upstream and downstream of the bridge than at the sampling site.

**Site 8** – (GPS Lat. 39.9811, Long. -93.2011) This site is located where Delco Road crosses Locust Creek. It is approximately 3.75 miles downstream of the Browning WWTF. Adjacent lands are planted in row crops. The substrate here is primarily sand. The banks are steep and mostly covered in herbaceous vegetation near the bridge. There are more trees upstream and downstream of the bridge than at the sampling site.

### **3.0 Methods**

#### **3.1 Field Procedures**

Prior to each sampling event, ESP personnel calibrated water quality field instruments (pH, specific conductivity, and dissolved oxygen) per manufacturers' specifications. ESP staff determined pH, specific conductivity, dissolved oxygen, and temperature of all surface water grab samples at the time of collection. Field measurements are summarized in Appendix B, Table 1.

##### **3.1.1 Surface Water Samples**

All samples were collected between 8:55 and 13:45, and analyzed for *E. coli* within six hours of collection in accordance with [MDNR-WQMS-109](#) standard operating procedure. Grab samples were taken in-stream by immersing sample containers directly into the stream. *E. coli* samples were collected in 120 ml sterile containers. Personnel stood downstream of the sampling location and care was taken to minimize sediment disturbance during collection. Samples collected for analysis at Truman State University were collected in a similar manner. Dr. Cynthia Cooper collected samples on July 11, 2007 and July 24, 2007 in containers supplied by Truman State University. On July 26, 2007, August 1, 2007, and August 7, 2007 ESP staff collected the side-by-side samples in the manner described above and transported the samples to the laboratory at Truman State University. Sampling data are summarized in Appendix B and C.

##### **3.1.2 Discharge Measurements**

In accordance with standard operating procedure MDNR-WQMS-113, Flow Measurement in an Open Channel, stream discharge was measured at all stations within one day of each sampling trip: July 7, 2007, July 25, 2007, August 2, 2007, and August 6, 2007. A Marsh-McBirney, Inc. Model-2000 FLOMATE Meter was used at all stream sites. Discharge data have been summarized in Table 1.

The Milan WWTF operator recorded discharge from the plant and precipitation in Milan and provided ESP with this data (see Figures 7-8).

### **3.2 Chain-of-Custody**

All samples received a numbered label and were placed on ice in a cooler. The corresponding label number was entered onto a chain-of-custody form indicating the date, time, location of collection, and parameters to be analyzed. ESP staff retained custody of the samples until relinquishing them to the laboratory sample custodian within the Environmental Services Program in Jefferson City, Missouri for analyses. Chain of custody was also maintained for the samples collected by ESP staff and analyzed at Truman State University.

### **3.3 Analyses Requested**

All samples collected were submitted to the ESP Chemical Analysis Section for nitrate + nitrite as nitrogen, ammonia as nitrogen, total nitrogen, and total phosphorus analyses. Water Quality Monitoring Section staff performed the *E. coli* analysis in accordance with [MDNR-WQMS-109](#) standard operating procedure, *Analysis of E. coli and Total Coliforms Using IDEXX Colilert and Quantitray Test Method*, based on USEPA approved methods. Samples collected for Truman State University were also analyzed using the IDEXX Colilert and Quantitray Test Method.

### **3.4 Quality Assurance/Quality Control**

#### **3.4.1 QA/QC Methods**

All analyses were in accordance with the *Fiscal Year 2008 Quality Assurance Project Plan for Wasteload Allocation/Special Studies* (FY-2008 QAPP).

#### **3.4.2 QA/QC Samples**

Duplicate samples were collected on July 24, 2007 and August 1, 2007. Duplicate samples numbered 0708012 and 0708029 were collected at site 8.

### **4.0 Observations**

Water samples from all East Fork Locust Creek sites consistently appeared light brown to brown and turbid. Water samples from Locust Creek were clearer. Elmwood Creek water samples were a brownish color and turbid. On July 25, 2007, a thick black substance was noted on the creek bed along the northern edge of Elmwood Creek, which persisted until the end of the study.

The United States Geological Survey reports that the study area received average rainfall this year. Precipitation records are provided in Appendix D, Figure 7.

The geometric mean value at each site for all *E. coli* samples in East Fork Locust Creek increased as water traveled downstream from Highway N (see Appendix C, Figure 4). Results from discrete sampling events exhibited considerable variability at each East Fork Locust site (see Appendix C, Figure 2). Similar results were obtained in September 2006. Locust Creek had lower levels of *E. coli* upstream of its confluence with East Fork Locust than it did at

downstream sites. It appears that East Fork Locust may contribute to slightly elevated *E. coli* levels in Locust Creek. Similar results were obtained during the September 2006 study. The *E. coli* results suggest a cumulative effect from point (WWTFs) and non-point (agricultural runoff) sources contributing *E. coli* to East Fork Locust Creek throughout the entire study region. Concentrations of *E. coli* in Locust Creek were much lower. Whether this is due to decreased *E. coli* input, or the greater volume of water flowing (see Appendix B, Table 1) in Locust Creek is difficult to discern. Examination of aerial photos of the study area suggests that East Fork Locust drains primarily pasture, while Locust Creek drains more crop fields.

Statistical analysis showed some significant variation between sites. A One-Way ANOVA test showed that variation among all five sites was significant. However, a Tukey Test (pairwise multiple comparison) showed that the significant difference was between East Fork Locust and Locust Creek sites only. According to the Tukey Test, change in concentration between adjacent sites was not significant enough to rule out random variation.

Missouri Department of Natural Resources 10 CSR 20-7.031 states that for a stream designated WBC-B the geometric mean shall not exceed 548 mpn/100mL during the recreational season. This study revealed an exceedance of the water quality standard at site 5 (designated WBC-B), where the geometric mean for *E. coli* was found to be 1348.80 mpn/100mL. Similar results were obtained at this site in September 2006. The geometric mean at site 3 (541.86 mpn/100mL) was very close to the WBC-B water quality limit. The site 4 geometric mean (1112.64 mpn/100mL) was in excess of the WBC-B water quality limit, but this site is not designated for any whole body contact recreation (see Appendix B, Table 2).

The average nutrient concentration showed an inverse trend in relation to *E. coli* concentration (see Appendix C, Figures 4 and 5). Elmwood Branch, which receives PSF effluent north of Milan, was a significant source of ammonia, nitrite, nitrate, total nitrogen, and total phosphorus. As water traveled down East Fork Locust these nutrients were consumed by aquatic organisms and/or diluted by increasing flows. By the time East Fork Locust emptied into Locust Creek (nearly 15 miles downstream) nutrient input was negligible.

Side-by-side *E. coli* sampling and analysis by Truman State University yielded results comparable to those from the ESP laboratory. This increases our confidence in field techniques and reported results. These results have been summarized in Appendix C, Figure 6.

## **5.0 Data Reporting**

Analytical results are summarized in Table 1.

Submitted by:

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## **Appendix A**

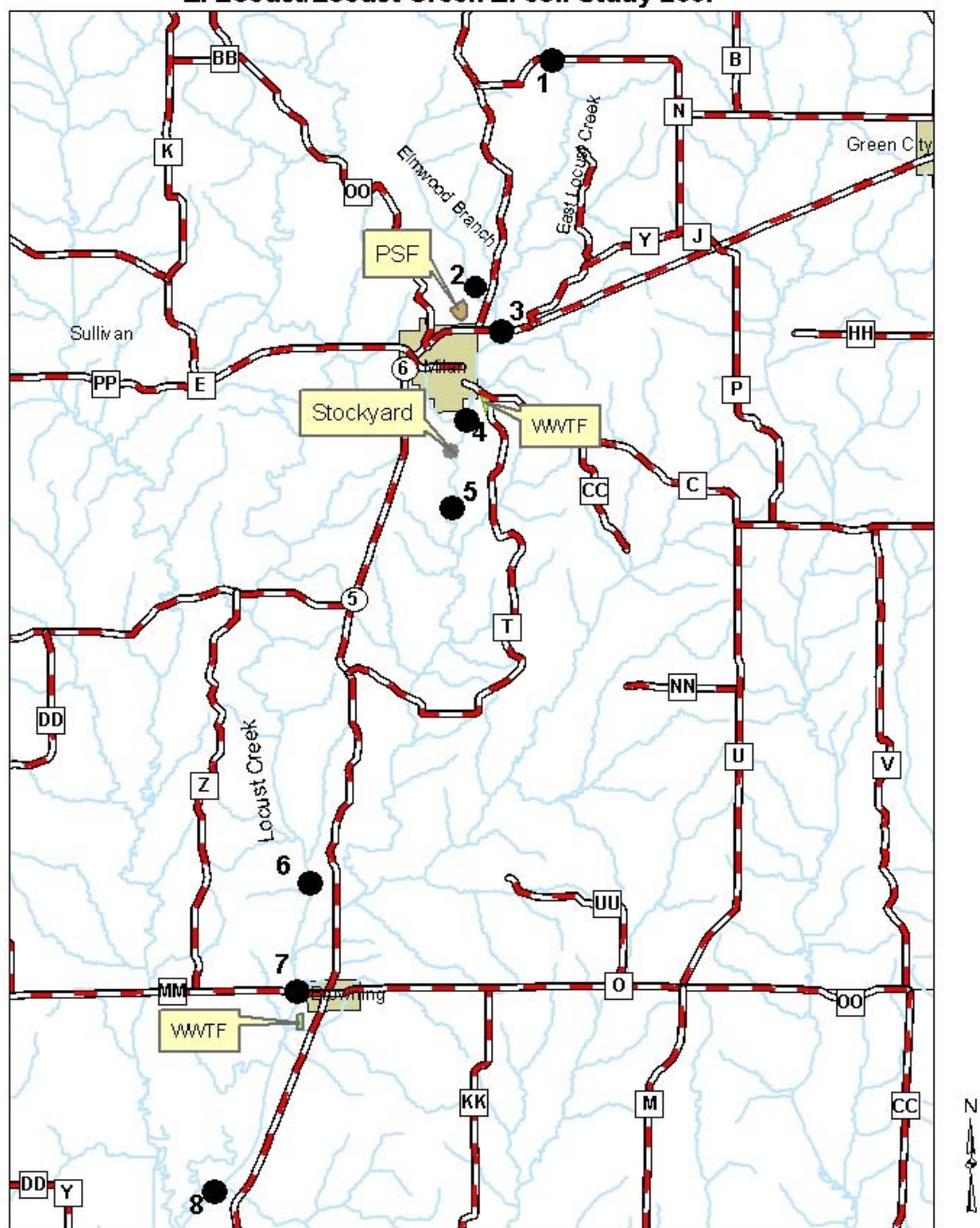
### **Site Map**

East Fork Locust and Locust Creek *E. coli* Study  
Sullivan and Linn Counties, MO

July – August 2007

Figure 1.

**E. Locust/Locust Creek E. coli Study 2007**



1 inch equals 2.439023 miles

**Appendix B**  
**Analytical Results**

East Fork Locust and Locust Creek *E. coli* Study  
Sullivan and Linn Counties, MO

July – August 2007

**Table 1. Analytical Results**

Sample #	Site	Date	Time	Flow <sup>1</sup> (cfs)	Dissolved Oxygen <sup>1</sup> (umhos/cm)	pH <sup>1</sup>	Specific Conductivity <sup>1</sup>	Temp <sup>1</sup> (C)	<i>E. coli</i> (mpn/100mL)	NH3 as N (mg/L)	Nitrate + Nitrite as N (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
0700781	1	7/11/2007	9:45	0.32	3.02	7.35	448	21.7	>2419.6	0.10	0.01	0.73	0.06
0708004	1	7/24/2007	10:25	0.00	5.61	7.90	512	23.6	613.1	0.03	0.01	0.74	0.07
0708013	1	7/26/2007	11:05	0.00	4.60	7.82	494	23.9	214	0.03	0.01	0.67	0.06
0708021	1	8/1/2007	14:00	0.00	6.70	7.69	502	28.4	21.6	0.03	0.01	0.66	0.02
0708251	1	8/7/2007	8:55	0.00	1.10	7.35	512	26.5	206	0.25	0.02	0.9	0.08
0700795	2	7/11/2007	10:20	2.76	6.77	7.45	1370	25.3	517.2	0.08	25.5	26.8	19.6
0708005	2	7/24/2007	10:44	0.98	8.60	8.47	1380	21.1	224.7	0.14	29.7	28.6	15.7
0708014	2	7/26/2007	11:25	0.98	8.00	8.37	806	23.3	210	0.22	14.2	14.9	18.2
0708022	2	8/1/2007	13:10	0.93	8.63	7.98	1390	27.0	308	0.14	22.3	24.5	20.6
0708252	2	8/7/2007	9:15	1.08	7.32	7.76	1450	24.5	411	0.14	37.6	40.0	17.7
0700796	3	7/11/2007	10:45	2.35	7.25	7.62	1050	23.0	579.4	0.10	18.1	18.4	10.1
0708006	3	7/24/2007	11:00	1.10	8.76	8.60	1100	20.6	290.9	0.14	21.3	21.3	9.35
0708015	3	7/26/2007	11:45	1.10	8.88	7.96	1260	22.2	148	0.23	14.0	13.3	10.1
0708023	3	8/1/2007	13:45	1.32	10.4	7.92	1300	28.5	1200	0.12	20.0	24.8	15.7
0708253	3	8/7/2007	9:30	0.99	6.42	7.45	1410	24.6	1550	0.13	35.0	38.5	15.4
0700797	4	7/11/2007	11:15	2.88	6.75	7.71	951	22.6	1199.9	0.14	13.8	14.7	6.86
0708007	4	7/24/2007	11:15	1.70	7.25	8.18	1060	22.8	>4839.2	0.14	13.7	14.2	6.98
0708016	4	7/26/2007	12:05	1.70	7.50	8.20	1140	24.6	222	0.16	11.2	11.9	7.08
0708024	4	8/1/2007	13:25	1.21	8.70	8.03	1160	28.5	816	0.11	21.8	24.9	7.66
0708254	4	8/7/2007	9:50	1.28	4.10	7.60	1220	25.8	1730	0.21	24.0	24.7	9.42
0700798	5	7/11/2007	11:45	2.93	9.20	7.89	950	24.0	1299.7	0.08	13.9	14.5	5.37
0708025	5	7/24/2007	11:43	1.93	9.21	8.41	1050	23.9	2419.6	0.13	7.34	10.3	5.36
0708017	5	7/26/2007	12:30	1.93	10.5	8.47	1060	27.1	980	0.13	9.84	10.3	4.97
0708025	5	8/1/2007	12:40	1.52	13.0	8.39	1110	29.5	1200	0.05	9.90	0.30	4.44
0708255	5	8/7/2007	10:15	1.57	6.85	7.87	1150	26.9	1200	0.16	5.09	6.30	5.63
0700799	6	7/11/2007	12:10	12.5	5.30	7.77	371	26.7	6.0	0.03	0.01	0.35	0.10
0708009	6	7/24/2007	12:05	4.09	6.60	8.47	391	24.1	9.8	0.03	0.01	0.33	0.05
0708018	6	7/26/2007	12:55	4.09	5.85	8.13	383	25.1	5.2	0.03	0.01	0.31	0.03
0708026	6	8/1/2007	12:20	1.48	6.59	7.72	400	26.5	10.8	0.03	0.01	0.30	0.01
0708256	6	8/7/2007	10:35	1.18	5.48	7.72	412	27.5	17.1	0.03	0.01	0.32	0.05

**Table 1. Analytical Results continued**

Sample #	Site	Date	Time <sup>1</sup>	Flow <sup>1</sup> (cfs)	Dissolved Oxygen <sup>1</sup> (umhos/cm)	pH <sup>1</sup>	Specific Conductivity <sup>1</sup>	Temp <sup>1</sup> (C)	<i>E. coli</i> (mpn/100mL)	NH3 as N (mg/L)	Nitrate + Nitrite as N (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
0700800	7	7/11/2007	12:25	23.5	8.49	7.77	472	26.4	65.7	0.03	0.01	0.40	0.07
0708010	7	7/24/2007	12:20	6.16	9.72	8.43	515	26.1	44.6	0.04	0.02	0.38	0.04
0708019	7	7/26/2007	13:05	6.16	9.70	8.17	503	27.1	37.3	0.03	0.02	0.37	0.02
0708027	7	8/1/2007	12:00	3.75	10.3	7.62	528	27.9	26.6	0.03	0.01	0.34	0.03
0708257	7	8/7/2007	10:50	4.25	7.05	7.63	538	26.5	56.5	0.06	0.03	0.40	0.01
0708001	8	7/11/2007	12:45	N/A	9.29	8.00	473	25.5	49.7	0.03	0.02	0.41	0.07
0708011	8	7/24/2007	12:35	6.35	10.4	8.40	487	25.6	40.8	0.08	0.04	0.41	0.02
0708012	8 Dup	7/24/2007	12:40	6.35	10.4	8.40	487	25.6	30.1	0.07	0.04	0.41	0.04
0708020	8	7/26/2007	13:25	6.35	9.40	7.96	486	28.2	48.1	0.05	0.03	0.39	0.01
0708028	8	8/1/2007	11:45	6.20	8.68	7.65	501	26.3	63.1	0.05	0.03	0.35	0.01
0708029	8 Dup	8/1/2007	11:50	6.20	8.68	7.65	501	26.3	102	0.05	0.03	0.37	0.01
0708258	8	8/7/2007	11:10	6.05	6.55	7.66	507	27.2	135	0.05	0.02	0.36	0.04

<sup>1</sup> Field Measurements**Table 2. *E. coli* Geometric Mean**

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
GeoMean (mpn/100mL)	269.33*	314.55	541.86	1112.64*	1348.80	8.92	43.97	60.84

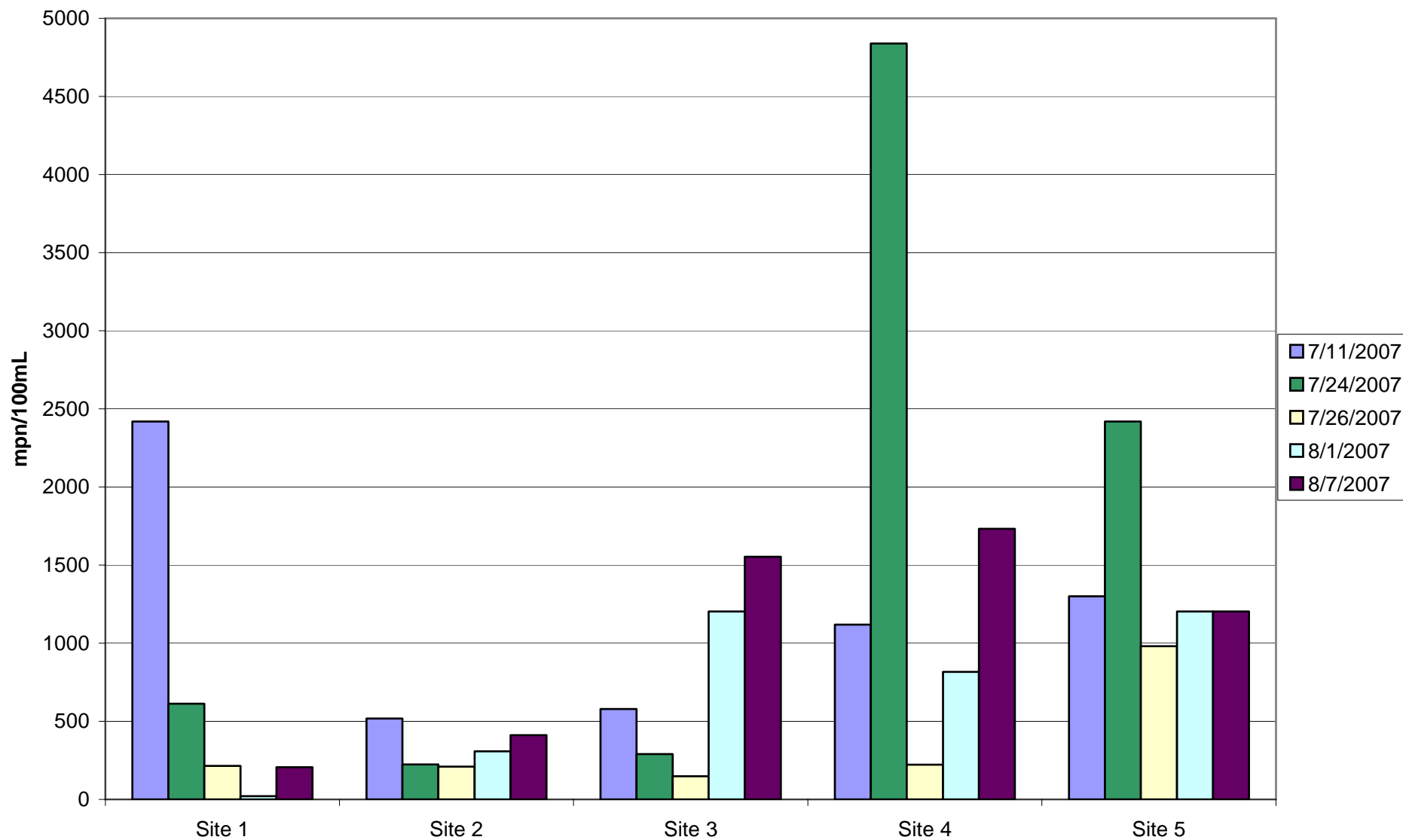
\*Calculation of geometric mean requires that all *E. coli* results use solid numbers; for sites that had results > the maximum detectable value, the maximum detectable value was used in the calculation (e.g. >2419.6 = 2419.6). For reported results see Table 1.

**Appendix C**  
***Eschericia coli* and Nutrient Charts**

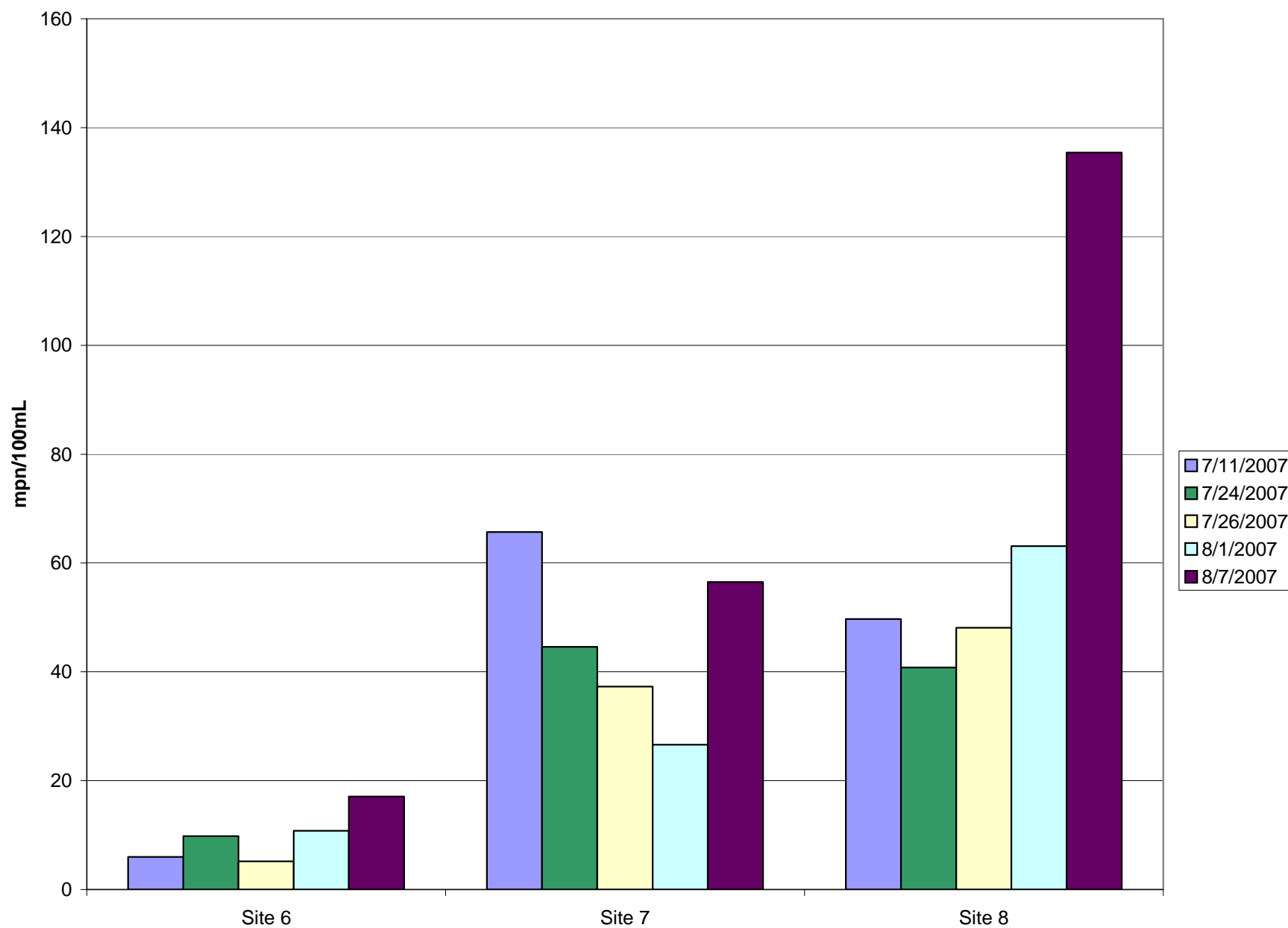
East Fork Locust and Locust Creek *E. coli* Study  
Sullivan and Linn Counties, MO

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**Figure 2. East Fork Locust Creek and Elmwood Creek *E. coli* Results (raw numbers) July 11 – August 7, 2007**

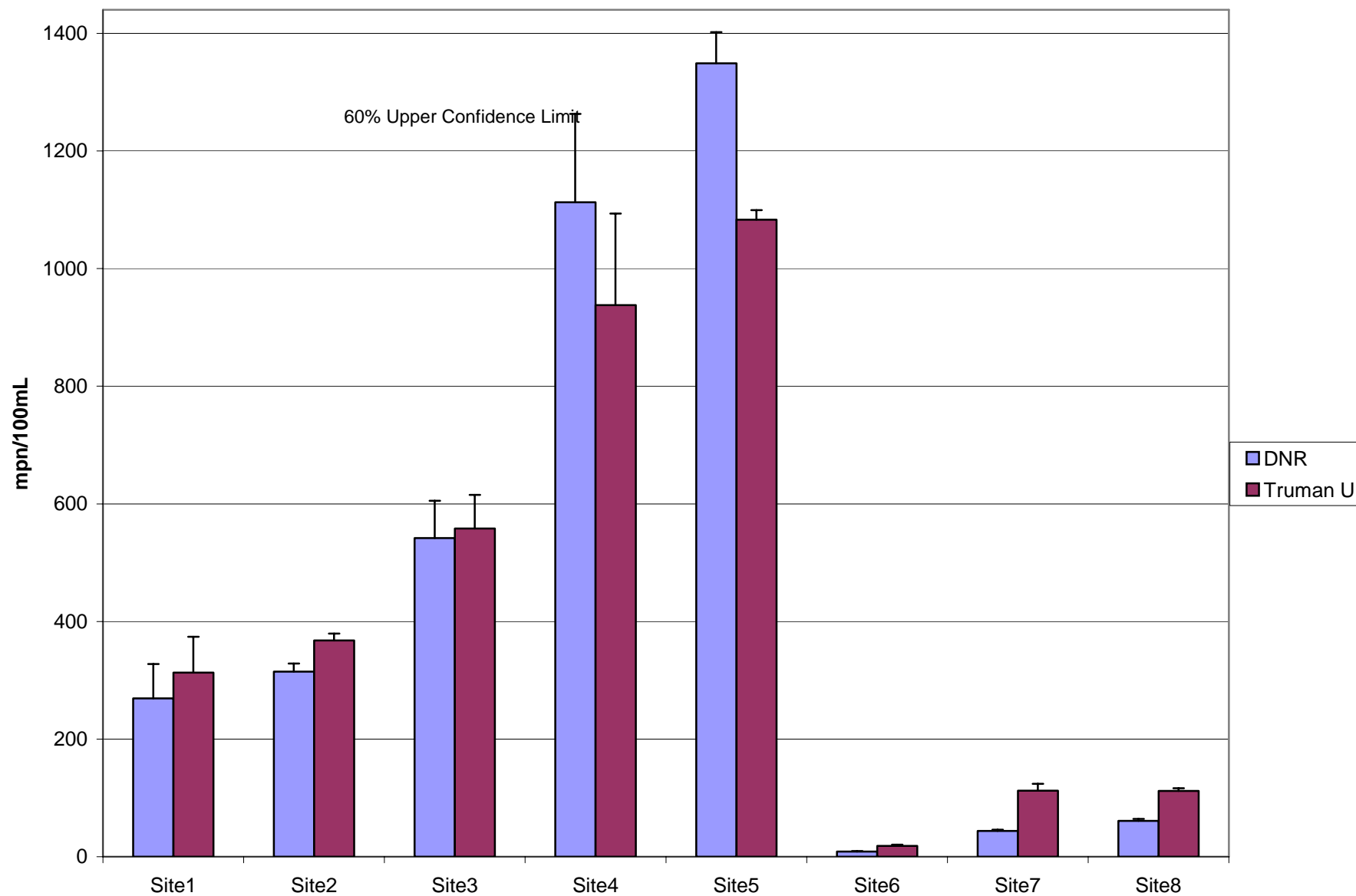


**Figure 3. Locust Creek *E. coli* Results (raw numbers) July 11 – August 7, 2007**



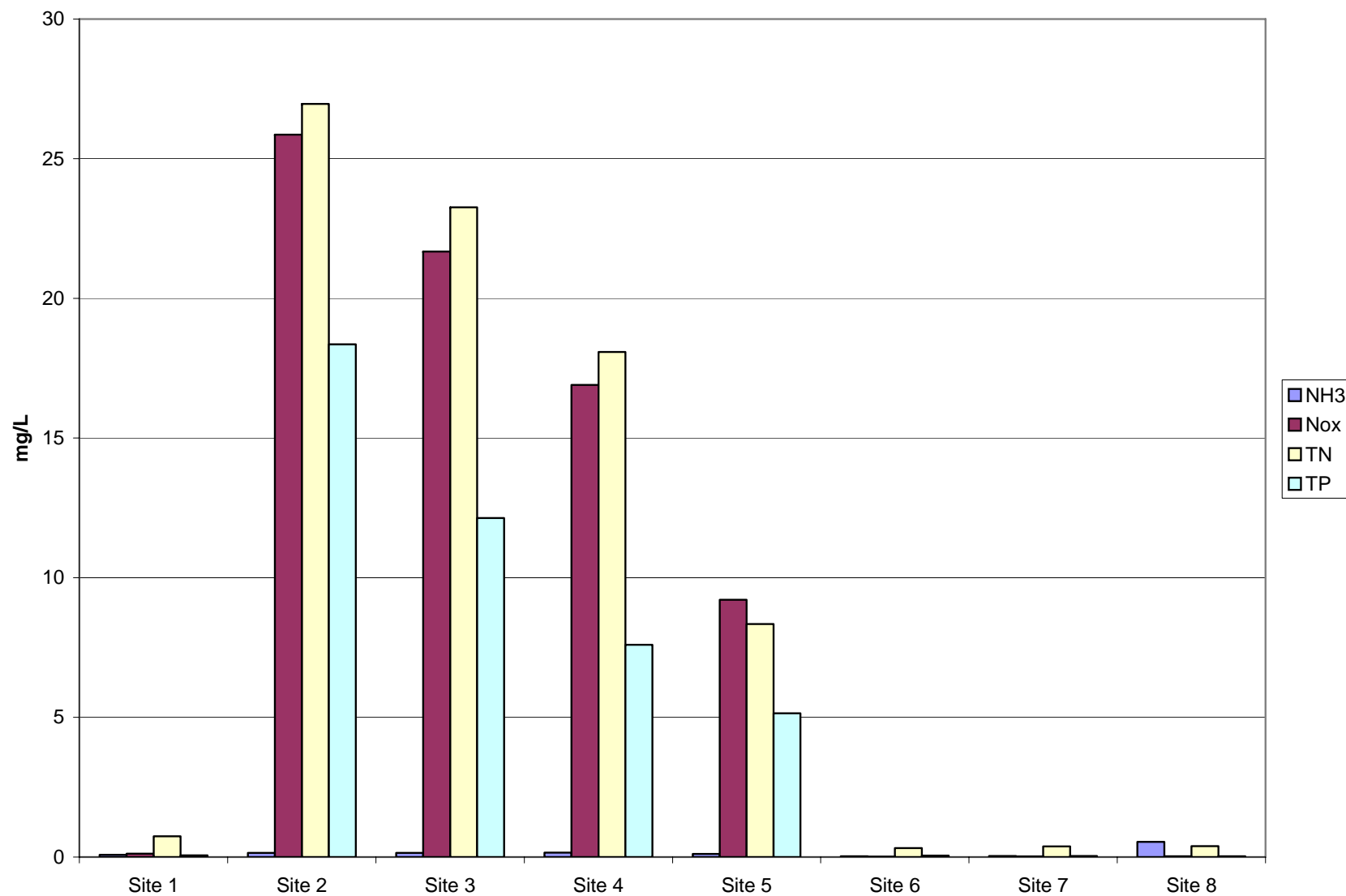


**Figure 4. *E. coli* Geometric Mean\* on East Fork Locust Creek, Elmwood Creek, and Locust Creek July 11-August 7, 2007**

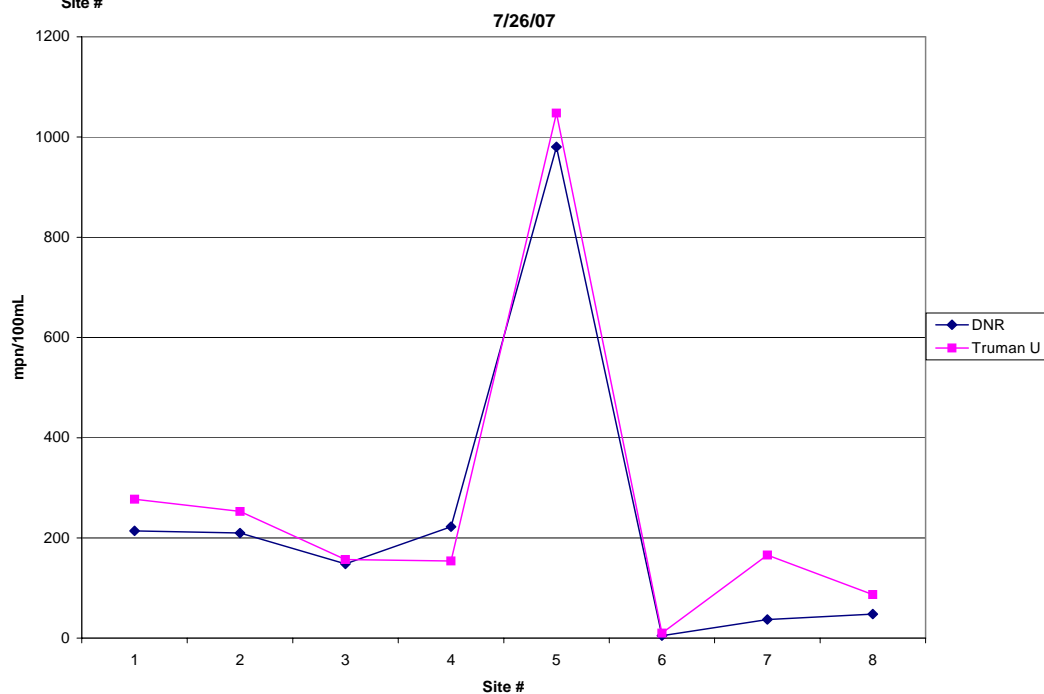
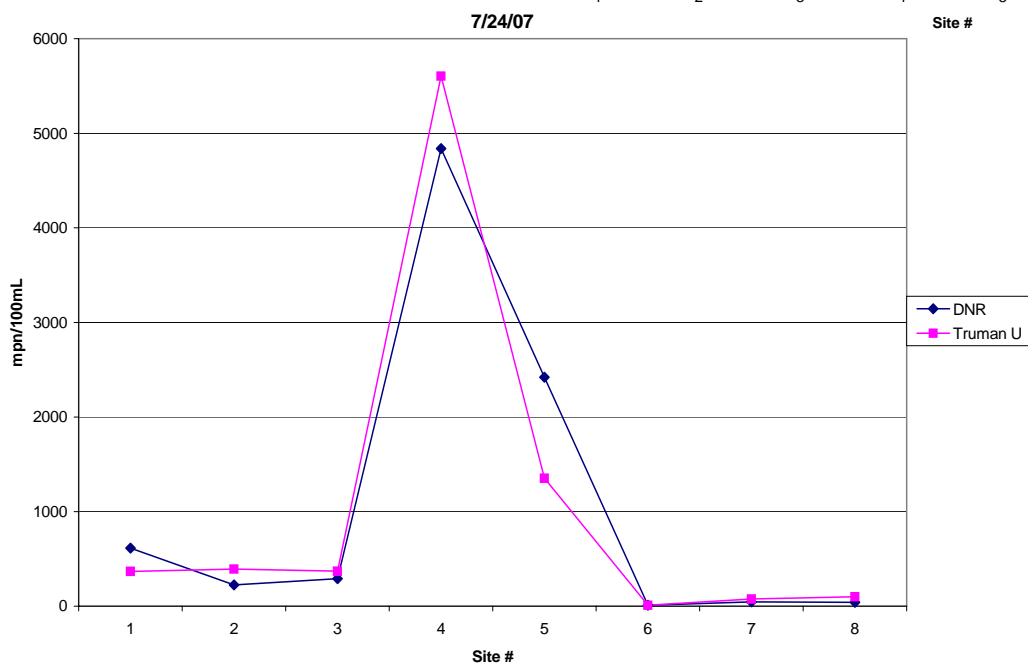
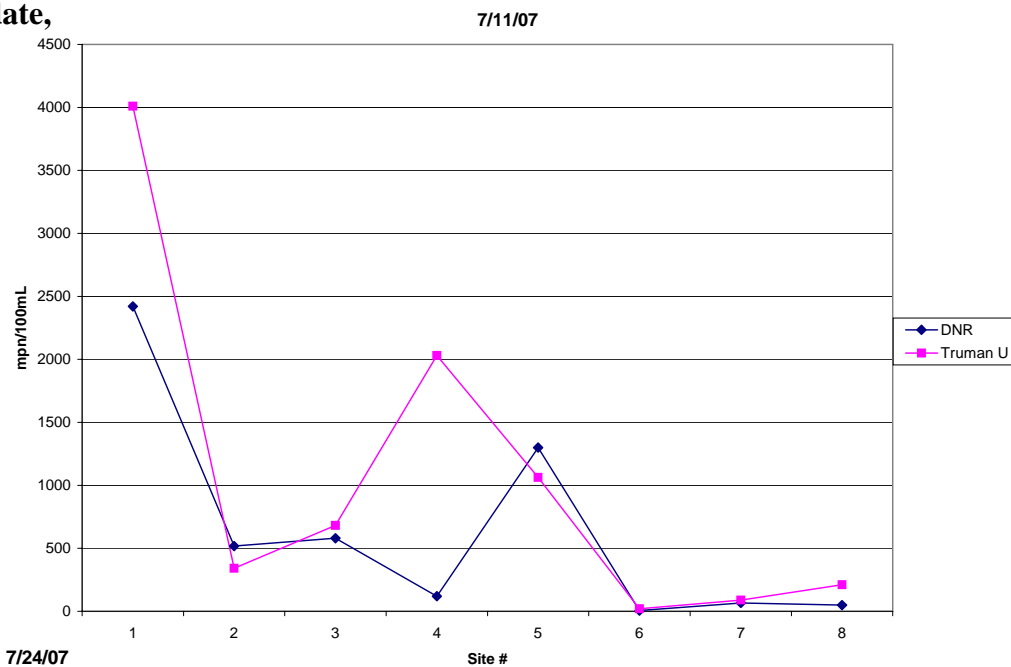


\*Calculation of geometric mean requires that all *E. coli* results use solid numbers; for sites that had results > the maximum detectable value, the maximum detectable value was used in the calculation (e.g. >2419.6 = 2419.6). For reported results see Table 1.

**Figure 5. Average Nutrient Concentration at Each Site July 11 – August 7, 2007**

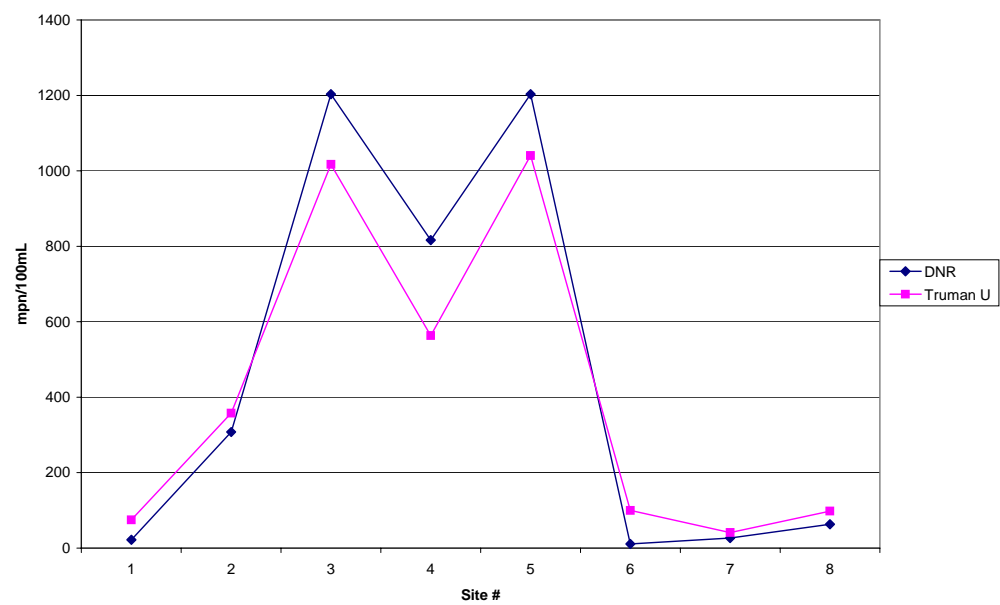


**Figure 6. Comparison, by sample date, of DNR *E. coli* results vs. Truman State University results**

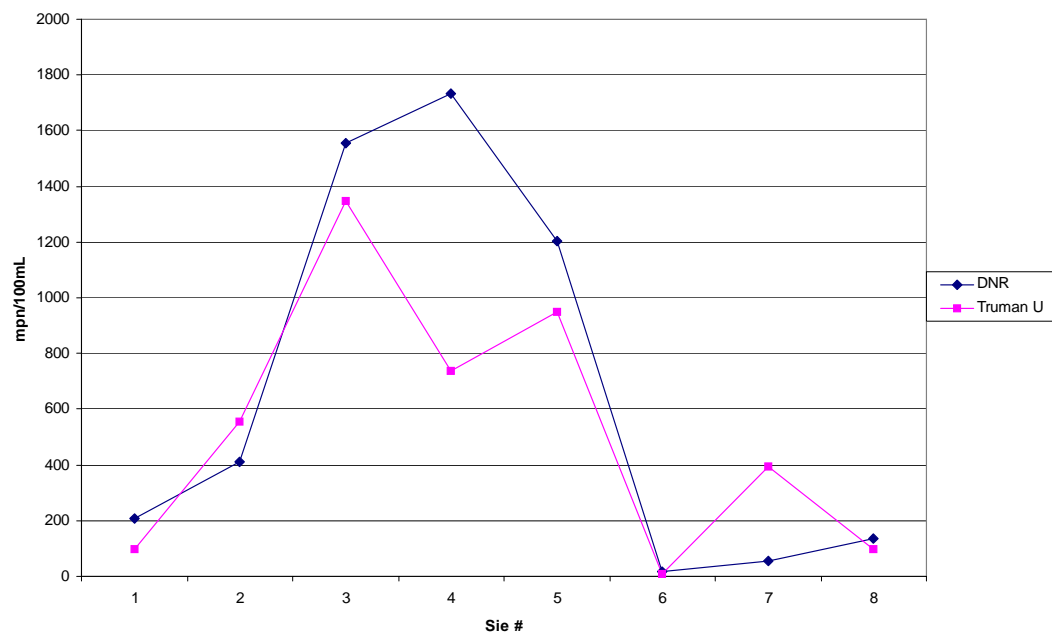


**Figure 6. Continued- Comparison, by sample date, of DNR *E. coli* results vs. Truman State University results**

8/1/07



8/7/07

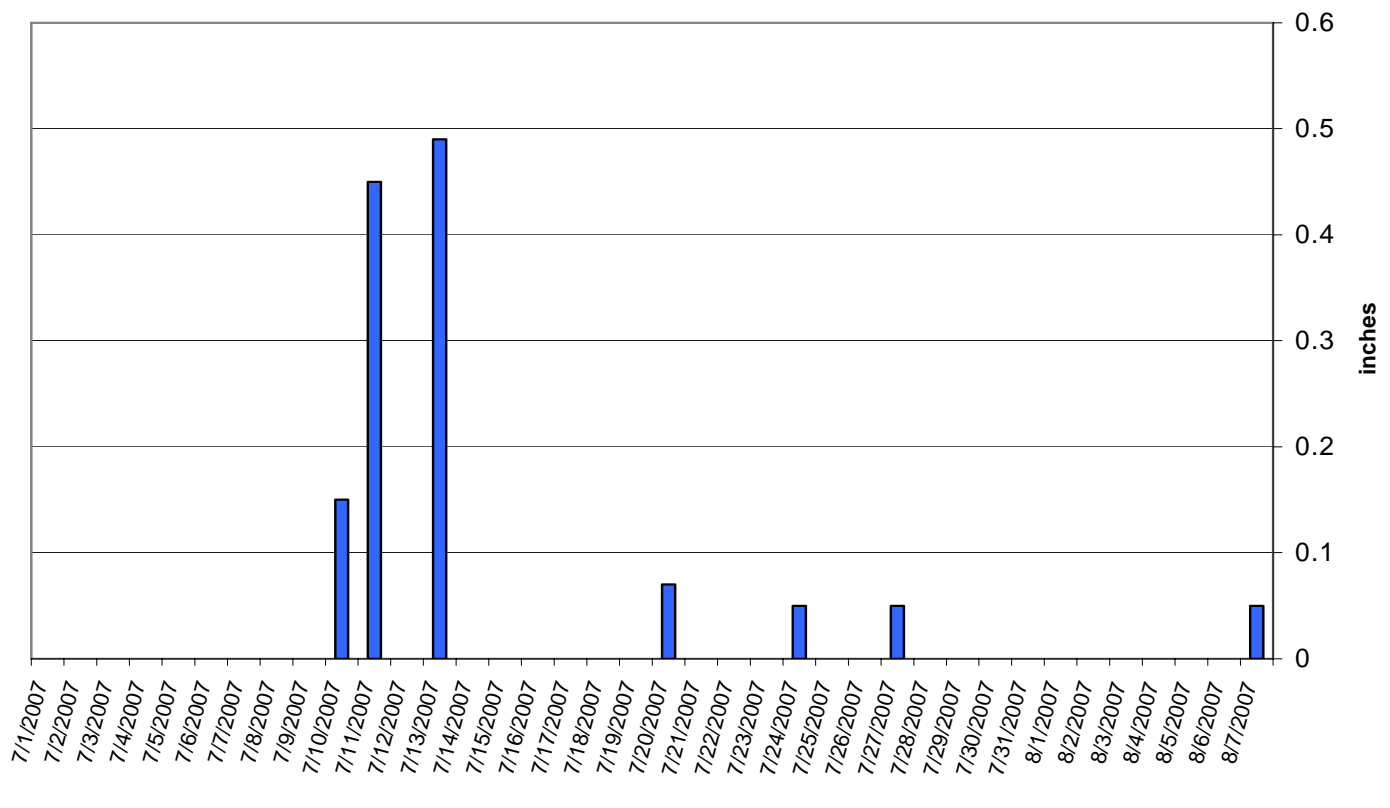


**Appendix D**  
**Precipitation and Discharge**

East Fork Locust and Locust Creek *E. coli* Study  
Sullivan and Linn Counties, MO

July – August 2007

**Figure 7. Precipitation in Milan**



**Figure 8. Milan WWTF Discharge in Million Gallons Per Day (MGD)**

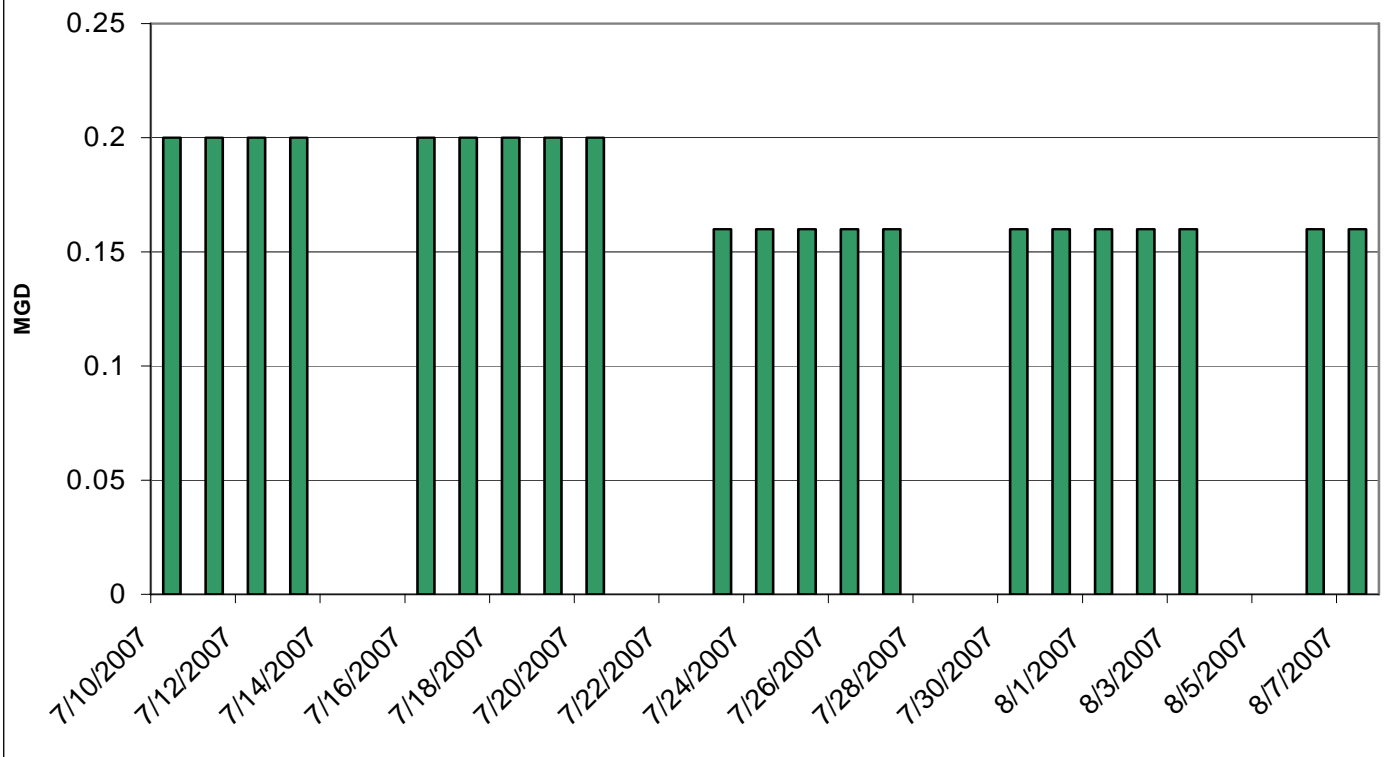


Figure 9. USGS Flow - Locust Creek, Linneus MO

